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Lumber Recovery From Ponderosa Pine in Northern California

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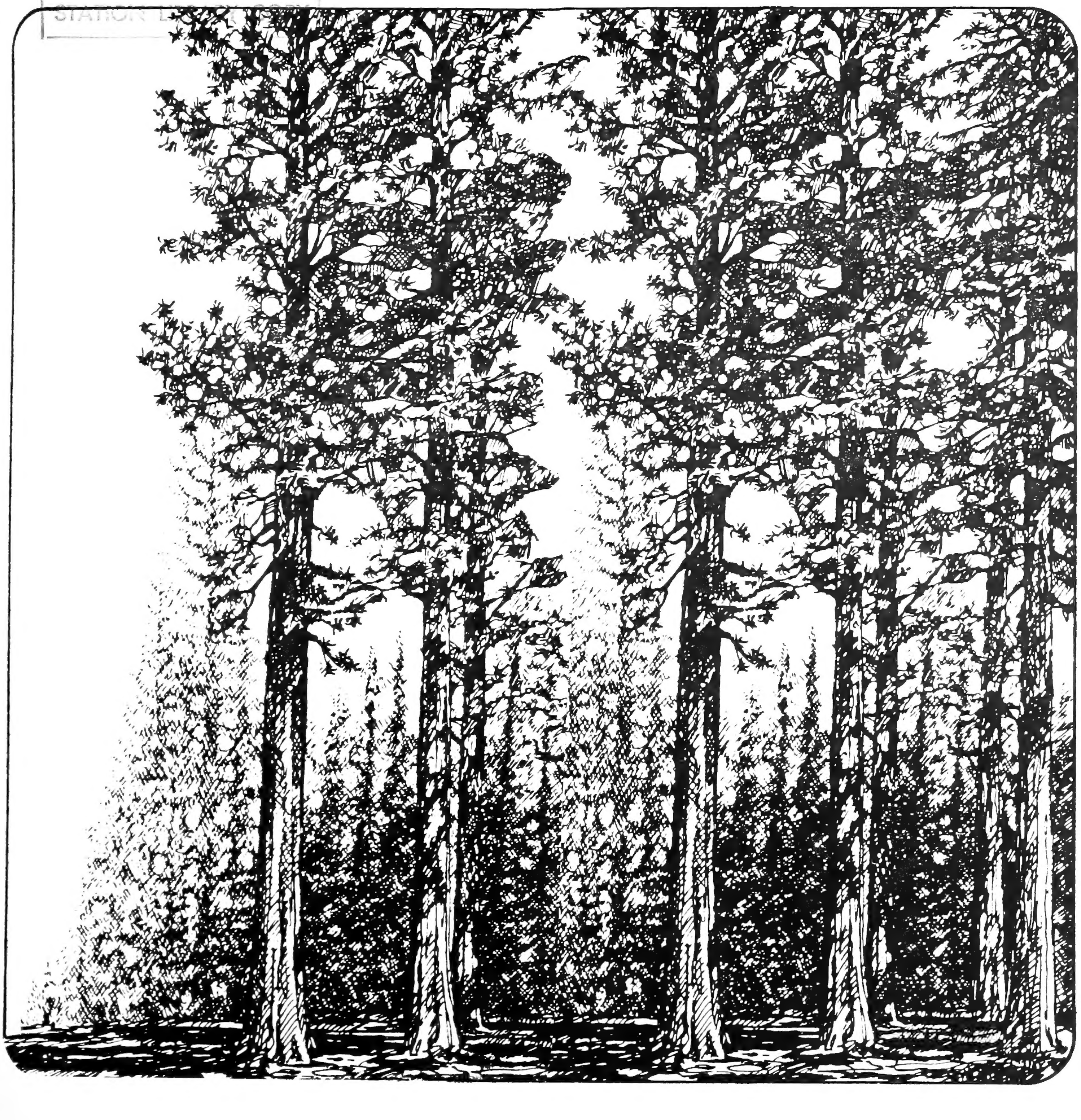

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Abstract

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Lumber recovery information from 942 logs from old- and young-growth ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) trees in northern California is presented. More than 58 percent of the lumber volume was found in 5/4 Shop, Moulding, and Select grades. About 25 percent of the total lumber volume was Moulding, and 24 percent was Standard and Better Dimension. Lumber volume recovery is presented on the basis of cubic feet and board feet. Volume recovery varied by scaling diameter but not by log grade. Value recovery and percent volume by lumber grade did vary by log grade and diameter, but no difference was found between the grade 1 and the grade 2 logs.

Keywords: Lumber yield, lumber recovery, ponderosa pine, *Pinus ponderosa,* California (northern), northern California.

Research Summary

Lumber recovery information for 942 logs from old- and young-growth ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) trees in northern California is presented. Over 58 percent of the lumber is 5/4 Shop, Moulding, and Select grades. Nearly 25 percent of the total lumber volume was Moulding; 24 percent was Standard and Better Dimension.

Information is presented on the basis of cubic feet and board feet. Lumber volume recovery varies by scaling diameter but not by log grade. Cubic recovery percent is estimated for all the logs combined, and overrun is estimated separately for old- and young-growth logs. The overrun for old-growth logs smaller than 17 inches is slightly higher than the overrun for the young-growth logs because of the effects of taper and log length.

Lumber grade recovery varies by scaling diameter and log grade except for grade 1 and grade 2 logs. The percentage of higher grade lumber increased as diameter and quality of logs increased. The value recovery coincides with the lumber grade recovery. Lumber values were indexed to Western Wood Products Association quarterly prices to allow easier updating to current prices. An additional method is also presented that allows the direct estimate of lumber volume and value from the cubic volume of logs.

Contents

Introduction

Ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) is a major softwood species in the Western United States. In California, it makes up more than 19 percent of the commercial softwood timber volume (USDA Forest Service 1974). Since the last product recovery study was conducted on this species some 20 years ago, timber size, product mix, and product sizes have changed. Currently, more Dimension grades of lumber are being produced from ponderosa pine, and there has been a marked increase in the utilization of young growth. Because of these changes, a need has developed for up-to-date information on volume and grade recovery of lumber from ponderosa pine. Land owners and mill managers depend on current product recovery information to make decisions on timber appraisals and log allocation, and to insure efficient utilization. Information in this report is from a product recovery study conducted in 1978 in cooperation with Region 5 (Pacific Southwest Region) of the USDA Forest Service.

The objectives of this paper are to provide information on lumber volume recovery, lumber grade distribution, and value of logs from young- and old-growth ponderosa pine trees in northern California. Specific objectives are to develop equations for predicting lumber volume, grade, and value yields, and to use these equations to test for differences between log grades.

Methods

Sample Selection

The study sample consisted of 150 old-growth and 60 young-growth trees selected from areas in the Sierra Nevada in the Plumas and Tahoe National Forests in California (fig. 1). Old-growth trees were selected from eight areas that covered the range of Dunning's Site Classes (Dunning 1942). Young-growth trees (less than 100 years old) were selected from two areas: a site 1 and a site 2 stand, both previously thinned. Both old- and young-growth samples were stratified by size (diameter at breast height—d.b.h.) and quality (grade of the butt log) (Gaines 1962). The sample trees ranged from 8 to 56 inches in d.b.h. for the old growth and from 8 to 32 inches for the young growth. The sample was selected by 2-inch diameter classes and averaged six trees per class. The sample was selected to cover the entire range of tree diameters and quality. The logs from these trees will not approximate the normal production run of diameters and grades, but they will provide recovery information that can be used for estimating recovery for any set of diameters and grades. Trees were felled and bucked according to normal industry practices in the area, except that the minimum log size included in this study was 6 inches in diameter inside bark at the small end and 8 feet in length.

Log Grading and Scaling

Field length logs were rolled out in the mill yard and scaled by both USDA Forest Service and industry scalers. Scribner segment scale with a 20-foot maximum length was taken (USDA Forest Service 1973). Gross cubic scale measurements were taken to one-tenth inch for diameter and to one-tenth foot for length. Bruce's (1982) butt log formula was applied to the butt logs, and Smalian's formula was applied to the upper logs to calculate the gross cubic scale volumes. Net cubic volume was determined by reducing the gross volume for voids, soft rots, and charred wood. Gaines' (1962) grading system was used for grading logs; grades 1, 2, 3, and 5 were used for the old-growth logs and grades 4 and 5 for the young-growth logs. Logs were rescaled after they were debarked and bucked into short logs on the mill deck. Information in this report is based on the Scribner scale taken on the mill deck and the cubic scale (with a 20-foot maximum length) taken in the mill yard.

Processing

The number of logs processed is shown in table 1. Production equipment in the sawmill includes: one single cut headsaw, one debarker, one single band vertical resaw, one single band horizontal resaw, two edgers, one gang bull edger, and one trim saw. Sawmill production averages about 150,000 board feet of lumber per shift.

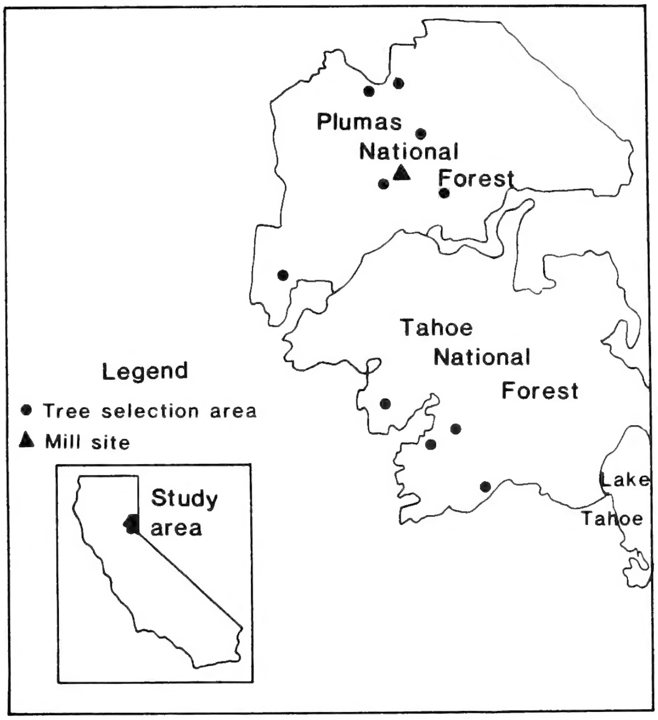

Figure 1.—Approximate location of study areas in the central Sierra Nevada.

Table 1—Number of logs by diameter and grade

	Grade				
Diameter class	1	2	3	5	Young growth
Inches			Number		
6-7				35	51
8-9				35	45
10-11			1	48	58
12-13			3	45	47
14-15			5	35	37
16-17		3	7	28	21
18-19	1	4	4	26	22
20-21	3	2	9	20	15
22-23	5	7	9	22	4
24-25	4	11	5	12	3
26-27	5	5	6	17	
28-29	5	7	6	13	
30-31	5	5	5	12	
32-33	5	3	10	10	
34-35	5	4	3	11	
36-37	8	5	7	2	
38-39	3	7	3	4	
40-41	9	5	4	4	
42-43	8	2	4	2	
44-45	5	4	5		
46-47	4	2		2	
48-49	4	1		1	
50-51	3				
Total	82	77	96	384	303

A system of paint colors and numbers was used in the mill to identify each board so that it could be identified by the log and tree from which it was cut. The lumber was kiln dried and then was graded under the supervision of a Western Wood Products Association (WWPA) inspector according to WWPA grading rules (Western Wood Products Association 1977). Each log was sawn to recover the maximum value. The following lumber grades were produced during the study: Select, Moulding, Shop, Dimension, and Common. Lumber was not all in the same condition when it was graded; Moulding and Select were rough, Shop was surfaced two sides, and Dimension and Common were surfaced four sides. A tally of length, width, thickness, and grade of each board was made. The lumber items were separated into 16 grades of lumber during the study. In this paper we have combined these grades into five grade groups:

Grade group	Lumber grades	Percent of lumber volume
Moulding and Better (Mldg & Btr)	B and Better Select	1.8
	C Select	2.6
	D Select	4.2
	Moulding	25.3
2 Shop	Factory Selects	.5
	1 Shop	4.5
	2 Shop	14.8
3 Shop	3 Shop	8.3
	Shop Out	1.6
Standard and Better (Std & Btr)	No. 2 and Better or Standard and Better	24.0
	3 and Better Common	.2
Utility and Economy (Util & Econ)	No. 3 or Utility	9.2
	Economy	2.5
	4 Common	.3
	5 Common	.1

Analysis

The objective of the analysis was to develop equations for predicting volume, grade, and value yields of lumber from logs from old- and young-growth trees.

Volume

Two approaches were used to analyze the volume of lumber recovered for the range of log scaling diameters (D): cubic recovery percent (CR%) and overrun (OR) (Fahey and Woodfin 1976). Cubic recovery percent is the ratio of cubic feet of lumber produced from a net cubic foot (CF) of log volume. Overrun is the percent of board-foot (BF) volume of lumber produced that is more than the net board-foot scale of that log. Cubic recovery percent and overrun vary by diameter, and generally a curvilinear function with diameter is used.

Cubic recovery percent.—Because both the lumber volume and the log volume are measured in cubic feet, cubic recovery percent gives the most accurate representation of the lumber volume to log volume relationships (Fahey and Snellgrove 1982). Cubic recovery percent, therefore, was used to test the hypothesis that lumber volume recovery does not vary by log grade. Several curve forms using diameter and transformations of diameter ($1/D$, $1/D^2$) as independent variables were tried (singly or in combination) to find the regression equation that best fit each log grade. The selection of the final curve forms was based primarily on the regression model having the highest coefficient of determination (R^2) and/or the lowest mean square error (MSE). Covariance analysis was used to compare the four grades of old growth, the two grades and sites of young growth, and the old- and young-growth logs. All testing was done at the 0.05 level of significance. The initial analysis was done on rough green lumber, but regressions were also developed for cubic recovery of surfaced dry lumber and of rough green lumber and sawdust combined. Sawdust volume is found by multiplying one-half the saw kerf by the surface area of the board.

Overrun.—Overrun curves were fitted separately to old-growth and young-growth logs; model forms used were the same as for cubic recovery. Coefficient of determination and mean square residual statistics were again used in choosing the best fitting equation. Covariance analysis was used to test for differences between the equations for old- and young-growth logs.

Board feet per cubic foot of lumber.—Another ratio related to volume is board feet per cubic foot of lumber (BF/CF) (Fahey and Woodfin 1976). This is defined as the ratio of the board feet of lumber, measured in nominal dimensions, to cubic feet of rough green lumber, measured in actual dimensions. This ratio is used to convert cubic volume of lumber, predicted from CR%, to board feet or marketing units. This ratio also varies by diameter, and various transformations of D were tested as independent variables. Board feet per cubic foot was regressed against diameter for old- and young-growth logs, and comparisons were made to test for differences between them.

Grade

Regression lines were fitted to cumulative percent volume by lumber grade groups (Util & Econ, Util & Econ and Std & Btr., and so forth) for each log grade. Again, D, $1/D$, and $1/D^2$ were tested to find the best fitting regression. Covariance analysis was used to test for differences in percent of the amount of cumulative lumber grades among log grades.

Value

Value is normally expressed as either value per unit of log scale or value per unit of lumber. The total value of each log is found by multiplying the volume of lumber in each grade by its appropriate price. The prices used to calculate the total log value were taken from the WWPA December 1982 quarterly price index list (appendix 1). These log values include only lumber value, not the value of chips, other byproducts, or costs.

In this analysis, our objective is to evaluate the effects of log grade on value to determine if the log grades are effectively separating the resource quality. Average value, dollars per thousand board feet lumber tally ($/MLT), was used to test for differences in log grades. Average value per unit of lumber is the best indicator of differences between log grades because it reflects only the difference in inherent biological qualities (growth patterns, decay) and mismanufacturing and does not include bias caused by scaling.

The independent variables and transformations used for volume recovery were also used in the analysis of value. Model forms chosen were again based on R^2 and MSE statistics. The regression lines were plotted and covariance analysis was used to test for overall differences between log grades. If differences existed, paired comparisons were made between adjacent log grades (grade 1 vs. grade 2, grade 3 vs. grade 5, and so forth).

Direct Product Estimators

The preceding methods are useful for predicting recovery volume and value of logs by diameter, but another method is used to directly predict the volume of lumber and byproducts and the value of the lumber from cubic scale volumes (Fahey and others 1981). Net cubic scale was used as the independent variable; and a linear regression was used to predict lumber volume, chip volume, and lumber value. Regression equations were estimated for predicting volume of both old- and young-growth logs. Comparisons were made to test for differences. For predicting value, separate equations were developed for each grade of old-growth logs and for all young-growth logs combined. These equations were then tested for differences.

Results and Discussion

Volume

Cubic recovery percent.—Cubic recovery percent was found to be independent of log grade for the four old-growth log grades; therefore, all the data for old growth were pooled. A comparison of two sites and two log grades of young-growth logs again showed no statistical difference. A comparison of young-growth versus old-growth logs showed a statistical difference but not a practical difference; therefore, the cubic recovery percent curves are based on the pooled study data. As shown in figure 2, CR% increased sharply from 5 to 15 inches, then leveled off. The low recovery from the smaller diameter logs indicates that mills are relatively inefficient in converting these logs to lumber; therefore, a higher percentage of the log volume ended up as chips or hog fuel. Curves for CR% of surfaced dry lumber and of rough green lumber and sawdust are also shown in figure 2. The percentage of cubic volume of the log that was converted to chips can be found by subtracting the percentage of cubic recovery of rough green lumber and sawdust from 100 percent. Percentage of cubic volume of the log converted to surfaced dry lumber, shrinkage and planer loss, sawdust, and chips by scaling diameter are presented in table 2.

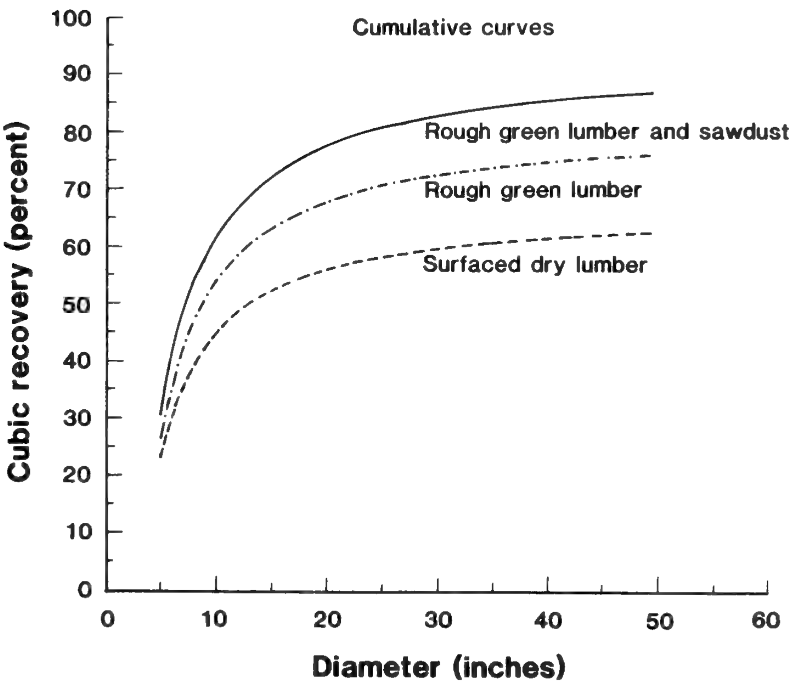

Figure 2.—Relationship of cubic volume recovery to scaling diameter for all logs combined. CR% increases as log size increases to 15 inches in diameter and then remains constant. The figure shows that the mill recovered a higher percentage of lumber volume from larger logs.

	R^2	MSE
CR% of surfaced dry lumber = 66.885 − 218.273(1/D)	0.518	0.0077
CR% of rough green lumber = 81.645 − 277.307(1/D)	0.557	0.0107
CR% of rough green lumber and sawdust = 93.279 − 315.355(1/D)	0.554	0.0140

Table 2—Volume recovery information for ponderosa pine in northern California

Log diameter 1/	Cubic recovery percent				Scribner overrun		Board feet per cubic foot	
	Surfaced dry lumber volume	Shrinkage and planer loss	Sawdust	Chips	Old growth	Young growth	Old growth	Young growth
Inches	- - - -	- - - -	- - - -	Percent - - - -	- - - -	- - - -		
6	30	5	5	60	71	42	14.8	15.0
7	36	6	6	52	81	54	15.1	15.0
8	40	7	7	46	84	59	15.0	14.9
9	43	8	7	42	82	61	14.8	14.8
10	45	9	8	38	79	61	14.6	14.6
11	47	9	8	36	75	61	14.3	14.5
12	49	10	8	33	71	59	14.1	14.3
13	50	10	9	31	66	58	13.9	14.2
14	51	10	9	30	62	56	13.6	14.1
15	52	11	9	28	58	55	13.4	14.0
16	53	11	9	27	55	53	13.3	13.9
17	54	11	9	26	51	51	13.1	13.8
18	55	12	10	23	48	50	12.9	13.7
19	55	12	10	23	45	48	12.8	13.6
20	56	12	10	22	42	47	12.6	13.6
21	56	12	10	22	39	46	12.5	13.5
22	57	12	10	21	37	45	12.4	13.4
23	57	12	10	21	34		12.3	
24	58	12	10	20	32		12.2	
25	58	12	10	20	30		12.1	
26-29	59	13	10	19	26		12.9	
30-33	60	13	10	17	19		11.6	
34-37	61	13	11	16	14		11.3	
38-41	61	13	11	15	10		11.1	
42-45	62	13	11	14	7		10.9	
46-49	62	14	11	13	4		10.8	

1/ 4-inch diameter classes were used for diameters larger than 25 inches because predicted values change very little in this region of the curve.

Overrun.—The same model forms chosen for cubic recovery were used to develop separate regression equations for old- and young-growth logs. A comparison of the two equations showed a statistically significant difference (fig. 3). One reason the old-growth logs smaller than 17 inches have higher overruns is the effect of taper. The old-growth logs had a higher taper factor (0.24 inch per linear foot of log) than the young-growth logs (0.14 inch per linear foot of log). The taper is different because the small diameter old-growth logs are from the crown area whereas the young-growth logs of the same size are from the main bole of the tree. The overrun may also be affected by log length; the young-growth logs were bucked primarily into 16-foot lengths, and the small diameter old-growth logs were bucked into lengths ranging from 10 to 18 feet. The overrun for the young-growth sample is slightly higher than the old-growth sample for logs larger than 17 inches because of the change in product mix. Average percentage of overrun by scaling diameter is presented in table 2.

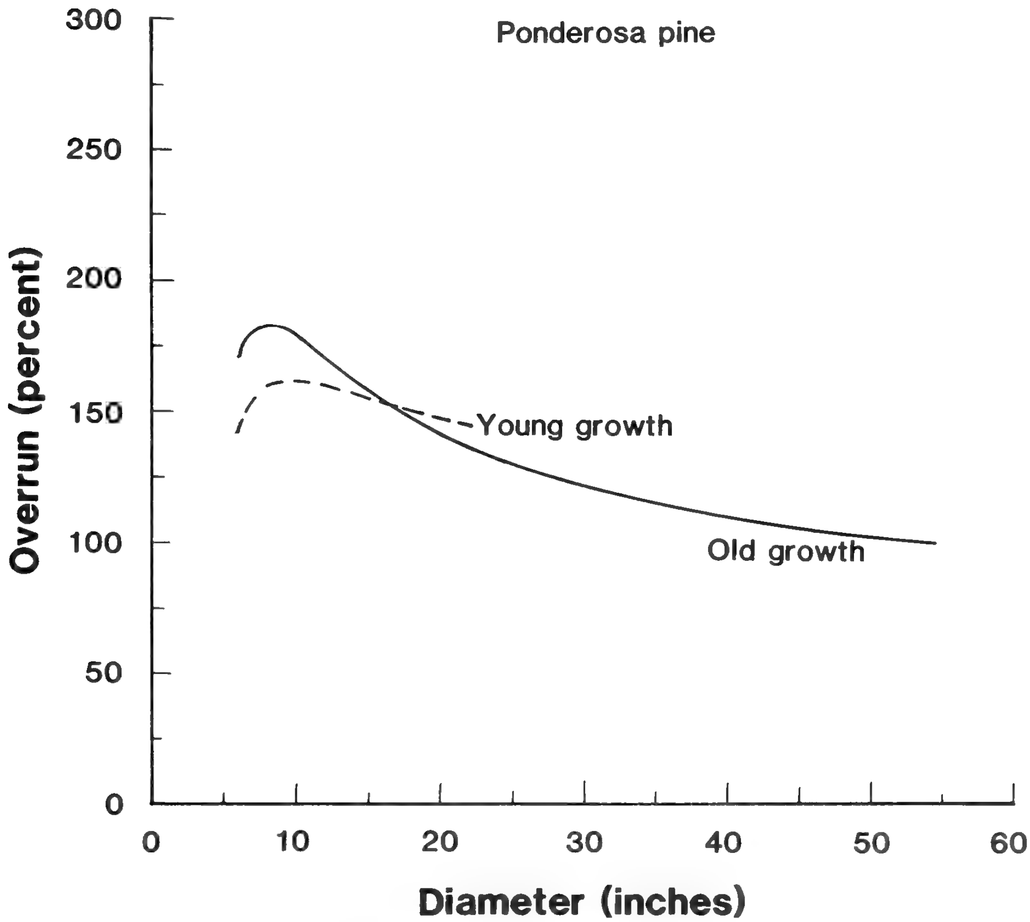

Figure 3.—Scribner overrun decreases as log size increases because of the combined effects of log scale, taper, and product mix. Within the 6- to 16-inch range the overrun for young-growth logs is lower than the overrun for old-growth logs.

		R^2	MSE
Old growth:	$OR = -31.807 + 1846.302(1/D) - 7388.072(1/D^2)$	0.292	1505
Young growth:	$OR = 7.588 + 1039.770(1/D) - 5007.926(1/D^2)$	0.024	1473

Board feet per cubic foot of lumber.—Comparisons of the regression lines for old growth and young growth showed a significant difference, so separate lines are shown in figure 4. The BF/CF ratios for both old growth and young growth are given by diameter class in table 2. This ratio is useful not only in converting from cubic feet to board feet but also in comparing the efficiency of different mills. For example, in this study the 2-inch Dimension and the 6/4 Shop were both sawn to

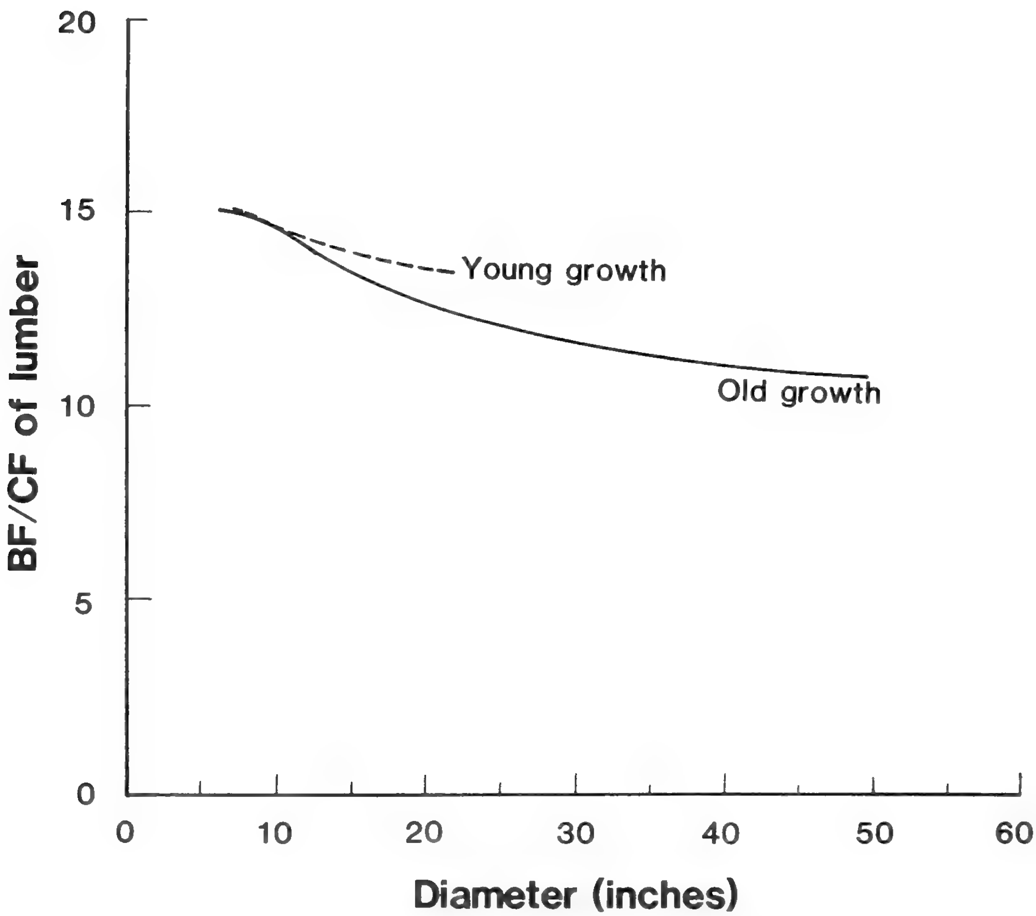

Figure 4.—The BF/CF ratio of lumber decreases as log size increases because of the change in product mix from 2-inch Dimension to 6/4 Shop.

		R^2	MSE
Old growth:	$BF/CF = 9.182 + 83.968(1/D) - 300.22(1/D^2)$	0.860	0.294
Young growth:	$BF/CF = 11.894 + 39.442(1/D) - 123.22(1/D^2)$	0.397	0.378

the same rough green thickness. As a result, both items used the same cubic volume of wood, but they have different board-foot volumes (table 3) because the board-foot volume is calculated with 1½ inches as the nominal thickness of the Shop whereas the Dimension is a full 2 inches. The board-foot volume of the 6/4 Shop will only be three-fourths that of the 2-inch Dimension; therefore, the BF/CF ratio of the Shop will be lower. This is evident in figure 4 where the BF/CF curve decreases with increasing log size because more Shop is manufactured from the larger logs.

Table 3—Comparison of board feet per cubic foot for 2 sizes of lumber products

Nominal inches	Actual inches	BF/CF 1/
6/4 x 12	1.66 x 11.75	11.07
2 x 12	1.66 x 11.75	14.76

1/ $\text{BF/CF} = \dfrac{144 \times \text{board feet per lineal foot}}{\text{actual thickness} \times \text{actual width}}$.

Lumber recovery factor.—A ratio related to volume that is commonly used in the wood products industry is lumber recovery factor (LRF); LRF is the board-foot volume of lumber produced from a cubic foot of log. It can be estimated by multiplying the CR% by the BF/CF ratio; it varies in the same way the BF/CF ratio does with changes in sizes of rough green products and in product mix.

One problem with both LRF and OR is that they are mill specific. Since both terms use a board-foot measure of lumber volume, they are directly tied to a particular mill's efficiency (Olson 1984). On the other hand, CR% is applicable to most mills; that is, most mills produce the same cubic volume of rough green lumber from logs of equal volume. The major differences in lumber recovery between mills are the changes in rough green "target" sizes of the lumber and the product mix. These differences are not accounted for when board foot is used as the measure of lumber, as in OR and LRF. When cubic feet are used to measure the lumber, the actual fiber used is measured and differences are accounted for. Since cubic feet are not used as a market unit, the BF/CF is an easy way to convert cubic feet to board feet for any mill. The BF/CF can also be used to convert published CR% values to actual production in board feet for a particular mill's rough green target sizes and product mix.

Grade

Regression lines were fitted to the cumulative percentages of lumber grades for each log grade. Because covariance analysis showed that there was little practical difference between the lumber grade percentages for grade 1 and grade 2 logs, recovery data for the two log grades were combined to produce a common set of curves. Separate curves were developed for grade 3, grade 5, and young-growth logs (fig. 5). These curves show that the percentage of higher grade lumber not only increases with higher log grades but also increases as log diameter increases for all log grades. Actual percentage of volume in each lumber grade rather than the cumulative percentage is given in appendix 2.

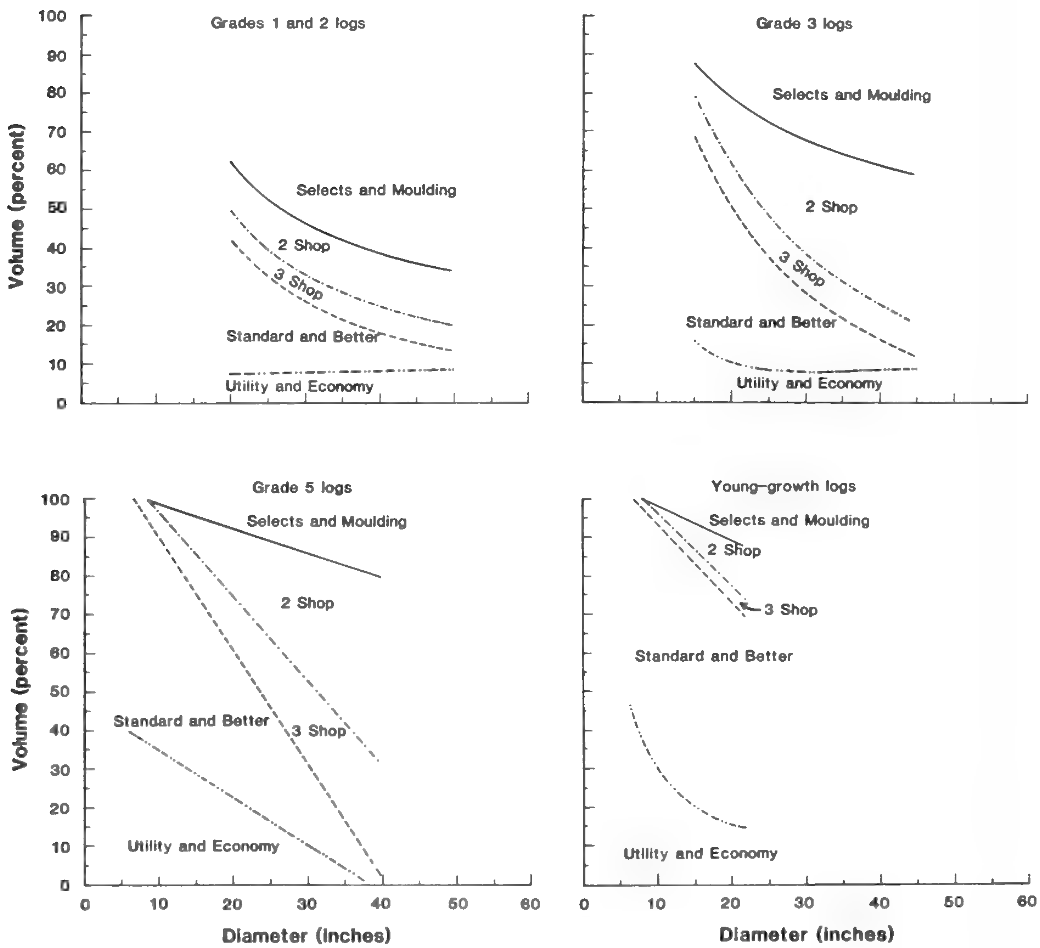

Figure 5.—Percentage of lumber volume by diameter is shown for each log grade. The general trend is that the higher grades of lumber (2 Shop, Moulding) are produced from the higher grade and larger diameter logs.

Value

Average value (dollars per thousand lumber tally—\$/MLT) was predicted for each log grade. The regression equations for the grades were compared and no statistical difference was found between grade 1 and grade 2. These results agree with previous results of the volume recovery and percent volume by grade recovery for these two log grades. Grade 1 and 2 logs were again combined to form a single regression line for estimating \$/MLT. The grading system separates the value for grade 3 and grade 5 logs (fig. 6). Young-growth logs from 5 to 15 inches in diameter have the same average lumber value as grade 5 logs of the same size. Young-growth logs larger than 15 inches have higher lumber values than the grade 5 logs, probably because most 15- to 22-inch young-growth logs are butt logs whereas the corresponding old-growth grade 5 logs are upper crown logs with many more larger knots.

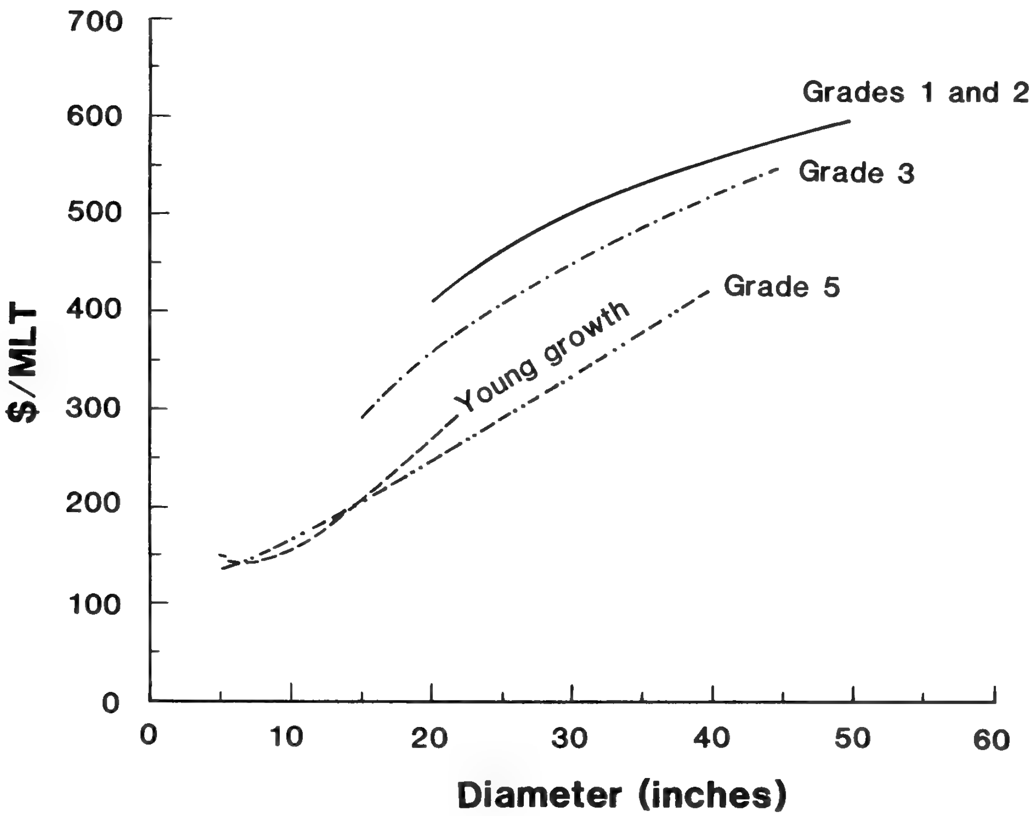

Figure 6.—The log grading system (Gaines 1962) for ponderosa pine effectively separates logs by their value. Although there is no difference between grade 1 and grade 2 logs, grade 3 and grade 5 logs are proportionally lower in value. The young-growth logs have a higher value than grade 5 logs larger than 15 inches because most young-growth logs of that size are butt logs.

		R^2	MSE
Grades 1 and 2:	$\$/MLT = 593.51 + 1.804(D) - 4382.97(1/D)$	0.321	7112
Grade 3:	$\$/MLT = 391.06 + 4.782(D) - 2587.62(1/D)$	0.590	4670
Grade 5:	$\$/MLT = 59.72 + 8.976(D) + 160.11(1/D)$	0.663	2902
Young growth:	$\$/MLT = -56.04 + 14.62(D)$	0.456	2168

Because the average lumber values used to estimate the regressions were based on WWPA quarterly index prices, adjustments to the value can be easily made when prices fluctuate. Values can be updated by multiplying the average value by the proportional change in the index. For example, the index price for coast-inland north ponderosa pine for December 1982 was $309.90, and the quarterly average for April-June 1983 was $394.27; the lumber prices can be updated by multiplying the average log value by $394.27 divided by $309.90.

Direct Product Estimators

Direct product estimators can be a useful tool for land managers or timber buyers. The advantage is that only cubic volume and number of logs are needed for predicting lumber and chip volume and lumber value. Lumber volume in board feet was predicted for old- and young-growth logs (fig. 7). A comparison of the regression lines showed that they were different which coincides with the results of the other recovery predictors for board feet, BF/CF, and OR. The volume of chips in cubic feet is predicted for all logs by use of the equation:
Chip volume (ft^3) = 2.084(number of logs) + 0.1687 (net cubic scale).
$r^2 = 0.580$; MSE = 63.

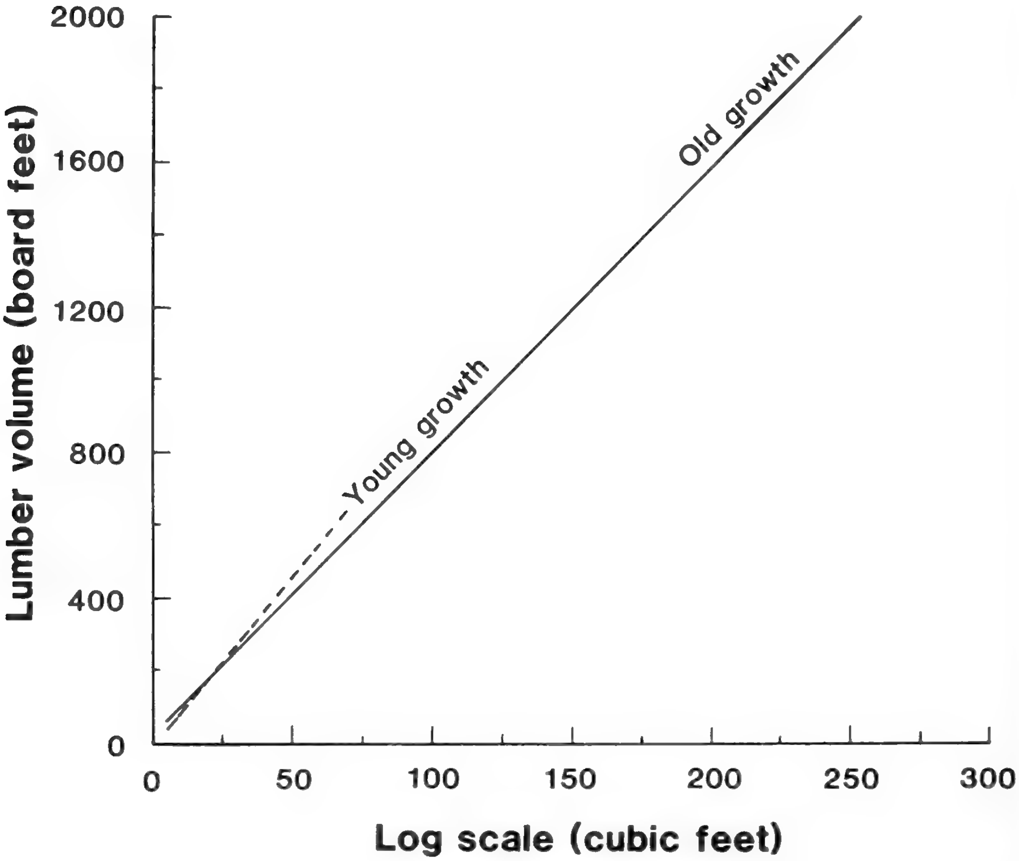

Figure 7.—The volume of lumber in board feet can be estimated from the net cubic scale.

Old growth: BF = 18.451(number of logs) + 7.835(net cubic scale).
R^2 = 0.982; MSE = 3630.
Young growth: BF = -10.471(number of logs) + 9.425(net cubic scale).
R^2 = 0.957; MSE = 625.

The lumber value was predicted for each grade of old growth; comparison showed that again no difference could be detected between grade 1 and grade 2 logs, but grade 3, grade 5, and young growth were different (fig. 8).

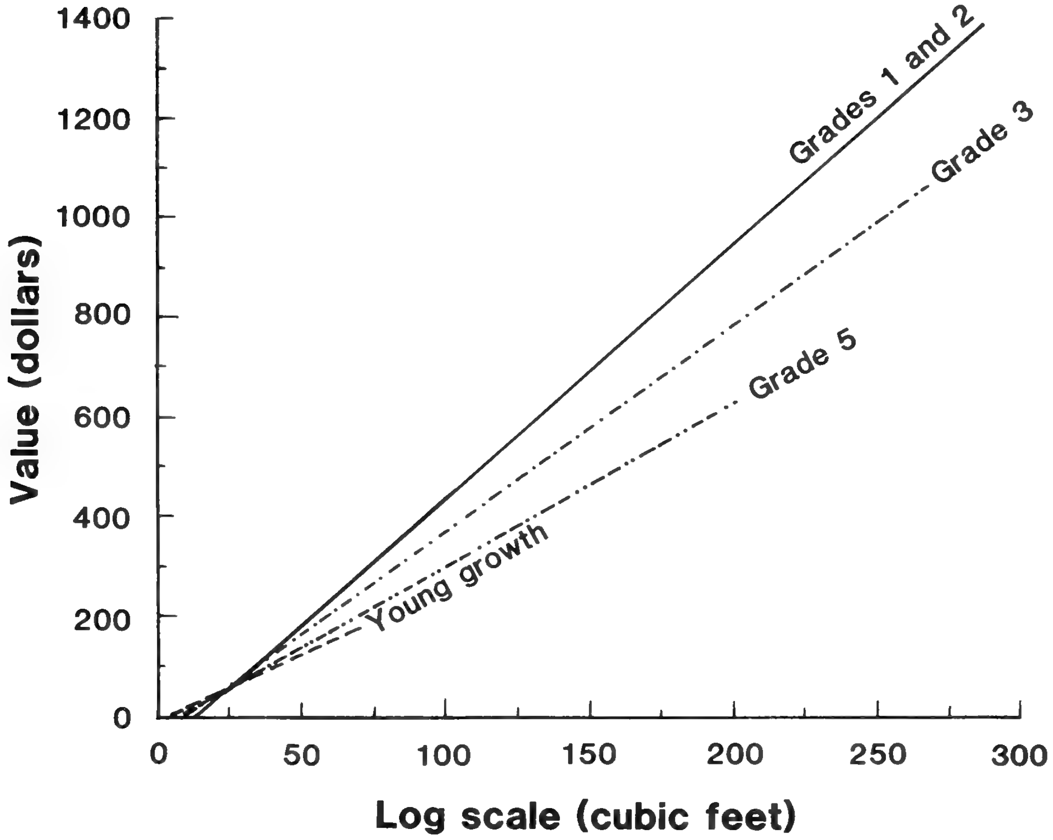

Figure 8.—The dollar value of the lumber from each ponderosa pine log can also be predicted from the net cubic scale for each log grade.

Grades 1 and 2:	Dollars = −65.259(number of logs) + 5.059(net cubic scale). $R^2 = 0.870$; MSE = 12346.
Grade 3:	Dollars = −45.790(number of logs) + 4.144(net cubic scale). $R^2 = 0.948$; MSE = 2566.
Grade 5:	Dollars = −28.069(number of logs) + 3.279(net cubic scale). $R^2 = 0.930$; MSE = 986.
Young growth:	Dollars = −14.439(number of logs) + 2.793(net cubic scale). $R^2 = 0.873$; MSE = 179.

Application

The information provided in this report can be used to aid mill managers and timber purchasers in decisionmaking. The following examples show two ways of estimating recovery of lumber volume and value. In the first example both the log diameter and either the net Scribner or the net cubic log scale are known, whereas the second example uses only the number of logs and the net cubic scale.

Example 1. Recovery information by diameter.

Sample logs:

			Net scale	
Diameter	Length	Log grade	Scribner	Cubic
(Inches)	(Feet)		(Board feet)	(Cubic feet)
20	16	5	280	43.6
35	16	1	840	113.3

A. Lumber volume can be predicted from either the net Scribner or the net cubic scale by the use of overrun and cubic recovery percent values from table 2.

1. For overrun, add 100 percent to the table 2 value and multiply the answer by the net Scribner scale:

280BF × 142 percent = 398 BF of lumber.
840BF × 114 percent = 958 BF of lumber.

2. For CR%, multiply the table 2 value[1] by the net cubic volume, then multiply the answer by the BF/CF ratio[2] for the number of board feet of lumber:

43.6 CF × 68 percent = 29.6 CF of lumber.
29.6 CF × 12.6 BF/CF = 373 BF of lumber.

113.3 CF × 74 percent = 83.8 CF of lumber.
83.8 CF × 11.3 BF/CF = 947 BF of lumber.

A slight difference may occur between the volumes predicted by the net Scribner scale and the net cubic scale because of the variation in each prediction equation.

[1] The cubic recovery percent should be based on rough green lumber and is equal to the sum of the table 2 values for the percent recovery for surfaced dry lumber and the percent recovery for shrinkage and planer loss.

[2] The BF/CF ratio may be either the value from table 2 or, if it is known, the value for a specific mill can be used for a more accurate estimate.

B. Once the board-foot volume of lumber has been estimated, the value of the lumber can be predicted two ways; from the average lumber value ($/MLT) or from prices for the individual lumber grades.

1. Using equations for $/MLT from figure 6, solve for the diameter and grade of the log, then multiply the $/MLT by the board feet of lumber:

$$\begin{aligned} \text{Grade 1: } \$/\text{MLT} &= 593.51 + 1.80D - 4382.97/D \\ &= 593.51 + 1.80(35) + 4382.97/(35) \\ &= 531\ \$/\text{MLT}. \\ \text{Lumber value} &= 531\ \$/\text{MLT} \times 0.947\ \text{MBF} = \$502.86. \end{aligned}$$

$$\begin{aligned} \text{Grade 5: } \$/\text{MLT} &= 59.72 + 8.98D + 160.11/D \\ &= 59.72 + 8.98(20) + 160.11/(20) \\ &= 247\ \$/\text{MLT}. \\ \text{Lumber value} &= 247\ \$/\text{MLT} \times 0.373\ \text{MBF} = \$92.13. \end{aligned}$$

These values can be updated to current WWPA index prices by multiplying the lumber value by the current index price and dividing the answer by the WWPA 1982 index price ($309).

2. For prices of individual lumber grades, the board-foot lumber volumes must be proportioned into the various lumber grades by use of the percentages by grade and diameter given in appendix 2. Current prices for the lumber grades can be applied to these volumes and then summed.

Example 2. Direct product estimations.

Sample logs (old growth):

Number of logs	Net cubic scale
	(Cubic feet)
1	100
20	1,500

Lumber volume can be predicted from the equations in the caption of figure 7.

For one log:

$$\begin{aligned} \text{Lumber volume (BF)} &= 18.541(\text{number of logs}) + 7.835(\text{net cubic scale}) \\ &= 18.541(1) + 7.835(100) \\ &= 802\ \text{BF of lumber.} \end{aligned}$$

For more than one log:

$$\begin{aligned} \text{Lumber volume (BF)} &= 18.541(\text{number of logs}) + 7.835(\text{net cubic scale}) \\ &= 18.541(20) + 7.835(1{,}500) \\ &= 12{,}123\ \text{BF of lumber.} \end{aligned}$$

Lumber value can also be predicted directly from net cubic scale by use of the direct product estimator equations from figure 8.

Metric Equivalents

1 inch = 2.54 centimeters
1 foot = 0.3048 meter
1 cubic foot = 0.02832 cubic meter

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Appendix 1

WWPA December 1982 quarterly price index list by lumber grade and size:

Thickness and grade	Price ($/MBF)
4/4, 5/4, 6/4:	
B and Better Select	1,069.74
C Select	1,069.74
D Select	972.73
Moulding	631.41
Factory Selects and 3 Clear	406.86
5/4 and 6/4:	
1 Shop	470.49
2 Shop	390.57
3 Shop	279.64
Shop Out	150.86
4/4:	
2 Shop	207.36
3 Shop	207.36
2-inch:	
No. 2 and Better or Standard and Better	175.65
No. 3 or Utility	118.64
Economy	77.34
1-inch:	
3 Common and Better	189.65
4 Common	106.92
5 Common	68.70

Appendix 2

Percentage of lumber volume by lumber grade for each log grade:

Diameter (Inches)	Moulding	2 Shop	3 Shop	Standard and Better	Utility and Economy
			GRADES 1 AND 2		
20	38	13	7	31	11
21	40	13	7	29	11
22	42	13	7	27	11
23	44	13	7	25	11
24	46	13	7	23	11
25	47	13	7	22	11
26-29	50	14	7	19	10
30-33	54	14	7	15	10
34-37	58	14	7	11	10
38-41	61	14	7	8	10
42-45	63	14	7	6	10
46-49	65	14	7	4	10
			GRADE 3		
15	12	9	11	52	16
16	14	11	11	49	15
17	16	13	12	46	13
18	17	15	12	44	12
19	19	17	11	42	11
20	21	18	11	40	10
21	22	20	11	37	10
22	23	22	11	35	9
23	24	23	12	32	9
24	26	24	11	30	9
25	27	25	11	29	8
26-29	30	28	11	23	8
30-33	33	31	10	18	8
34-37	36	34	10	12	8
38-41	38	36	9	8	8
42-45	40	39	9	4	8

GRADE 5

6	0	0	30	62	40
7	0	0	4	61	38
8	0	0	5	59	37
9	0	2	5	57	36
10	1	3	6	55	35
11	2	4	7	53	34
12	2	6	8	52	32
13	3	7	9	50	31
14	4	9	9	48	30
15	4	11	10	46	29
16	5	12	11	45	27
17	6	13	11	44	26
18	6	15	12	42	25
19	7	16	13	40	24
20	8	18	13	39	22
21	8	20	14	37	21
22	9	21	15	35	20
23	10	22	16	33	19
24	10	24	17	31	18
25	11	25	18	30	16
26-29	12	30	20	25	13
30-33	15	36	23	18	8
34-37	18	42	26	11	4
39-41	20	47	28	5	0

YOUNG GROWTH

6	3	1	3	46	47
7	2	0	2	54	51
8	1	0	3	60	36
9	1	0	3	65	32
10	0	0	3	68	29
11	0	1	3	69	27
12	2	1	3	70	24
13	1	3	3	70	23
14	4	3	3	69	21
15	5	4	4	67	20
16	7	6	3	65	19
17	8	8	4	62	18
18	10	10	4	59	17
19	11	13	5	55	16
20	17	13	4	51	15
21	16	17	5	47	15
22	20	18	5	43	14

Equations for the cumulative percent volumes by log grade and lumber grade:

		R^2	MSE
Grades 1 and 2:			
Utility and Economy	$= 0.092 + 0.346(1/D)$	0.010	0.0049
Standard and Better	$=-0.059 + 9.618(1/D)$	0.577	0.0062
3 Shop	$= 0.005 + 9.759(1/D)$	0.378	0.0144
2 Shop	$= 0.155 + 9.358(1/D)$	0.310	0.0219
Selects and Moulding	$= 1.0 - 2$ Shop		
Grade 3:			
Utility and Economy	$= 0.149 - 4.300(1/D) + 66.942(1/D^2)$	0.341	0.0167
Standard and Better	$=-0.257 + 18.343(1/D) - 63.851(1/D^2)$	0.852	0.0073
3 Shop	$=-0.218 + 20.972(1/D) - 87.320(1/D^2)$	0.727	0.0159
2 Shop	$= 0.385 + 10.121(1/D) - 41.352(1/D^2)$	0.361	0.0180
Selects and Moulding	$= 1.0 - 2$ Shop		
Grade 5:			
Utility and Economy	$= 0.470 - 0.012(1/D)$	0.181	0.0610
Standard and Better	$= 1.196 - 0.029(1/D)$	0.766	0.0156
3 Shop	$= 1.179 - 0.022(1/D)$	0.669	0.0152
2 Shop	$= 1.054 - 0.007(1/D)$	0.320	0.0094
Selects and Moulding	$= 1.0 - 2$ Shop		
Young growth:			
Utility and Economy	$= 0.018 + 2.755(1/D)$	0.158	0.0603
Standard and Better	$= 2.731 - 0.073(D) - 13.541(1/D) + 32.615(1/D^2)$	0.457	0.0133
3 Shop	$= 2.642 - 0.069(D) - 12.572(1/D) + 30.123(1/D^2)$	0.496	0.0101
2 Shop	$= 1.932 - 0.037(D) - 7.533(1/D) + 18.933(1/D^2)$	0.237	0.0075
Selects and Moulding	$= 1.0 - 2$ Shop		

*GPO 594 - 631 (1985)

Ernst, Susan; Pong, W. Y. Lumber recovery from ponderosa pine in northern California. Res. Pap. PNW-333. Portland, OR: U.S. Department of Agriculture, Pacific Northwest Forest and Range Experiment Station; **1985.** 22 p.

Lumber recovery information from 942 logs from old- and young-growth ponderosa pine (*Pinus ponderosa* Dougl. ex Laws) trees in northern California is presented. More than 58 percent of the lumber volume was found in 5/4 Shop, Moulding, and Select grades. About 25 percent of the total lumber volume was Moulding, and 24 percent was Standard and Better Dimension. Lumber volume recovery is presented on the basis of cubic feet and board feet. Volume recovery varied by scaling diameter but not by log grade. Value recovery and percent volume by lumber grade did vary by log grade and diameter, but no difference was found between the grade 1 and the grade 2 logs.

Keywords: Lumber yield, lumber recovery, ponderosa pine, *Pinus ponderosa*, California (northern), northern California.

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